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NRL Memorandum Report 1772

Stress-Corrosion Cracking Resistance of an 18Ni 200 Grade Maraging Steel Base Plate and Weld

G. SANDOZ AND R. L. NEWBEGIN

Physical Metallurgy Branch
Metallurgy Division

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NAVAL RESEARCH LABORATORY
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Cracking.

ABSTRACT

The stress-corrosion cracking resistance in salt water of a welded 18Ni 200 grade maraging steel weldment was investigated. Unexpectedly, the weld metal was found to be more resistant to stress-corrosion cracking than the base plates.

STATUS

This report completes this investigation; work on stress-corrosion cracking in general is continuing.

AUTHORIZATION

NRL Problem 63M04-08A
(ARPA Order 878)

INTRODUCTION

In late 1966, the Naval Research Laboratory received a segment of a steel weldment. The segment was made of vacuum induction melted 18Ni 200 grade maraging steel. Details of forming and processing history are not known. The segment was 15/16 in. thick and contained a TIG weld. In addition, the weld contained a small repaired area. NRL was requested to evaluate the base plate and weld with respect to fracture toughness and stress-corrosion cracking (SCC) susceptibility. This report describes the results of the stress-corrosion tests conducted by the Physical Metallurgy Branch.

PROCEDURE

This maraging steel is hardened by a solution anneal followed by an aging treatment. Upon inquiry, it was found that the segment sent to NRL had been solution annealed (1675°F for 2 hours, air cooled) but not aged. Instructions were received on the proper aging treatment. This was performed at NRL as follows:

1. Heat to 500°F.
2. Stabilize at 500°F by holding 15 minutes.
3. Heat to 850°F at a rate of 100°F per hour.
4. Hold at 850°F for 4 hours.
5. Cool at 250°F per hour.

After the 12 in. x 18 in. segment was fully heat-treated, it was cut into specimens of various types, as indicated in Fig. 1. The stress-corrosion cracking susceptibility specimens (designated S.C.C.) were designed for use in the NRL Cantilever Beam Test (1). The specimens were first notched and then precracked at the weld centerline by fatigue. After the SCC susceptibility at the weld centerline had been determined, the broken halves of specimens were notched and precracked within the two base plates, and the SCC susceptibility of these was then determined. In all cases the 3/4 in. wide specimens were side grooved about 6 percent on each side. The fatigue precracks were about 0.25 in. deep, and the SCC traveled through the plate thickness. A solution of 3½ percent NaCl in water was the environment used.

RESULTS

Some of the mechanical property data obtained on the heat-treated and aged segment, obtained by Mr. F. R. Stonesifer of the Mechanics Division and by Dr. P. P. Puzak of the Metallurgy Division, are given in Table 1. The yield strength of the base plate (Plate A) is 192.6 ksi and the weld 197.5. The fracture toughness index K_{Ic} of the base plate (Plate A) is between 165 and 213 ksi$\sqrt{in.}$, depending on whether the Kies formula or the Srawley-Brown formula is used and whether corrected or not for plastic zone size. By similar criteria, the metal of the weld centerline has a fracture toughness K_{Ic} of 129 to 140 ksi$\sqrt{in.}$

The results of the SCC susceptibility tests are shown in Figs. 2, 3, and 4. The curves are the usual initial K - time to fracture curves that are developed by use of the cantilever beam test (1). In Fig. 2, the results show that the threshold level K_{Iscc} of the metal at the weld centerline occurs at about 78 ksi$\sqrt{in.}$ The numbers adjacent to individual points indicate that a single specimen has been step-loaded (the load on an unbroken specimen in test is increased). The points marked W designate specimens from the weld repair area referred to previously. No effects of the weld repair itself on stress corrosion are apparent.

In the cantilever beam test, the value of stress intensity required to break a specimen in air is labeled K_{Ix}; it is a first approximation of K_{Ic}. Figure 2 shows that the value of K_{Ix} obtained for the centerline of the weld falls very slightly above the reported values of K_{Ic}. Within the weld area, differences between individual specimens might be expected.

In Fig. 3 the results of the stress-corrosion susceptibility tests on Plate A show a K_{Iscc} threshold value of 48 ksi$\sqrt{in.}$, compared with a K_{Ix} value of 146 ksi$\sqrt{in.}$ In this case the K_{Ic} values reported are somewhat higher than the K_{Ix} value.

The threshold value of K_{Iscc} for Plate B is identical with that of Plate A, 48 ksi$\sqrt{in.}$, as in Fig. 4. The value of K_{Ix} on this plate is 156 ksi$\sqrt{in.}$, a value somewhat higher than was obtained for Plate A. No determinations of K_{Ic} were made on Plate B.

The results show that the weld metal is more resistant to SCC than the base plates, a reversal of what is normally observed with weldments. It should be noted that previous tests on plates of 18Ni maraging steel of 200 ksi yield strength have shown K_{Iscc} values of over 70 ksi$\sqrt{in.}$; such values are high enough to match the K_{Iscc} values found for the weld metal in the present investigation.

REFERENCE

1. B.F. Brown and C.D. Beachem, "A Study of the Stress Factor in Corrosion Cracking by Use of the Pre-Cracked Cantilever Beam Specimen," Corrosion Science, Vol. 5, pp. 745-750, November 1965

TABLE 1

MECHANICAL PROPERTY DATA ON BASE PLATE A
AND ON THE WELD CENTERLINE

Notch Location	σ_y (ksi)	Kies Formula Average K_{Ic} (ksi$\sqrt{\text{in.}}$)		Srawley-Brown Formula Average K_{Ic} (ksi$\sqrt{\text{in.}}$)	
		Uncor.	Cor.	Uncor.	Cor.
Base Plate A	192.6	175	213	165	191
Weld Centerline	197.5	129	140	125	134

Fracture Mechanics Data -- F.R. Stonesifer (Mechanics Div.)

Yield Strength Data -- P.P. Puzak (Metallurgy Division)

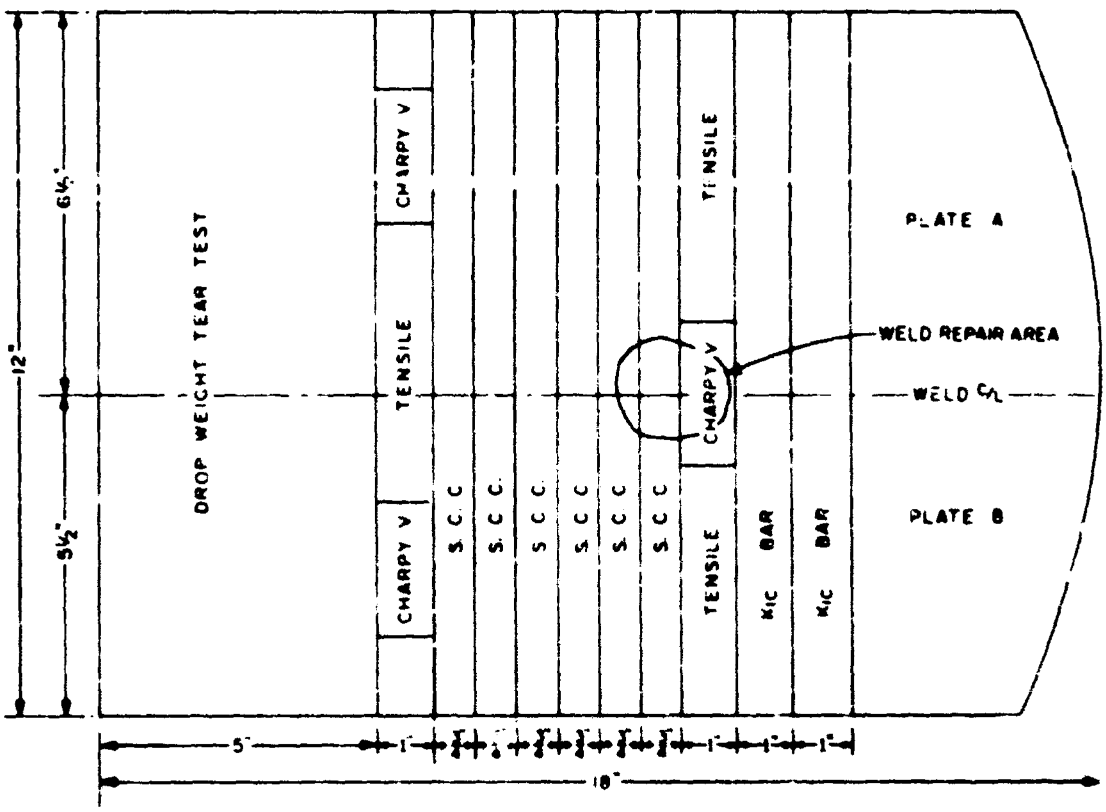

Figure 1 - Layout of segment showing how specimen blanks were taken

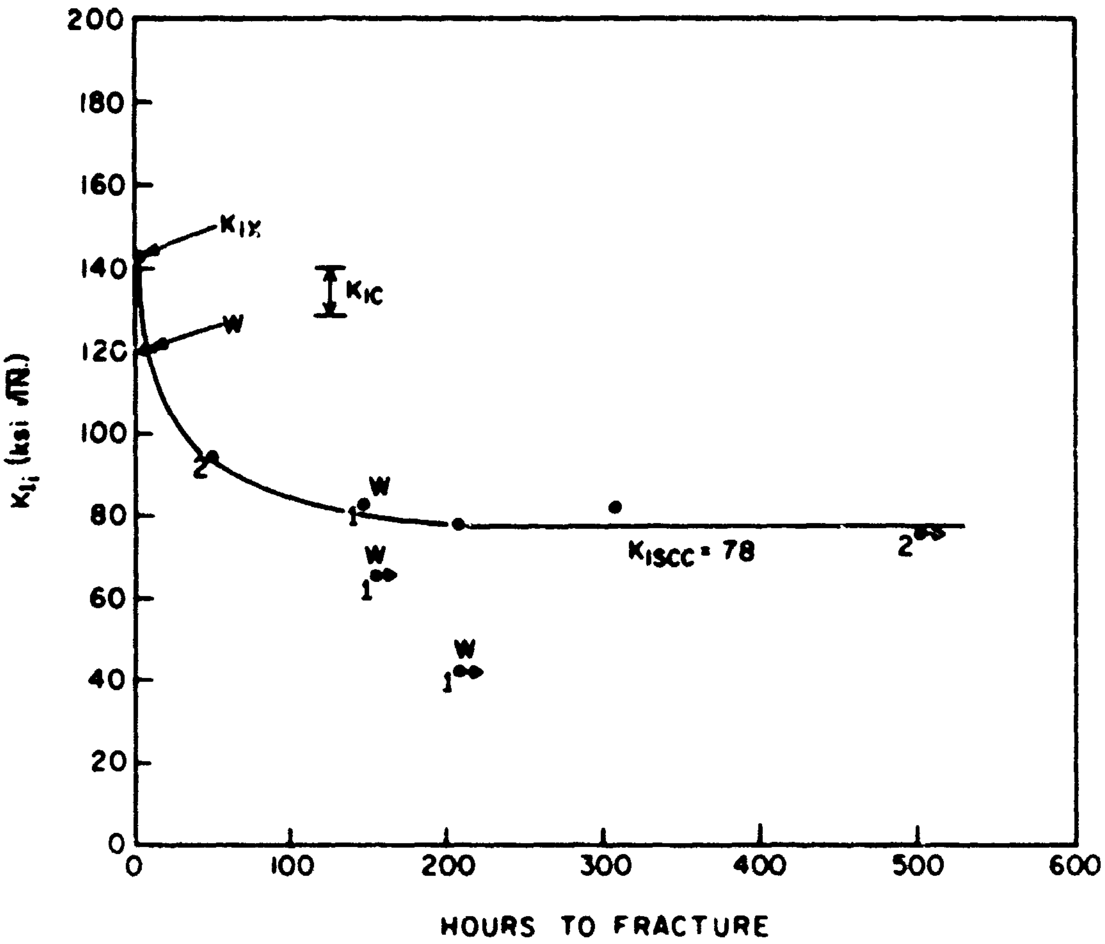

Figure 2 - Stress corrosion of weld centerline metal

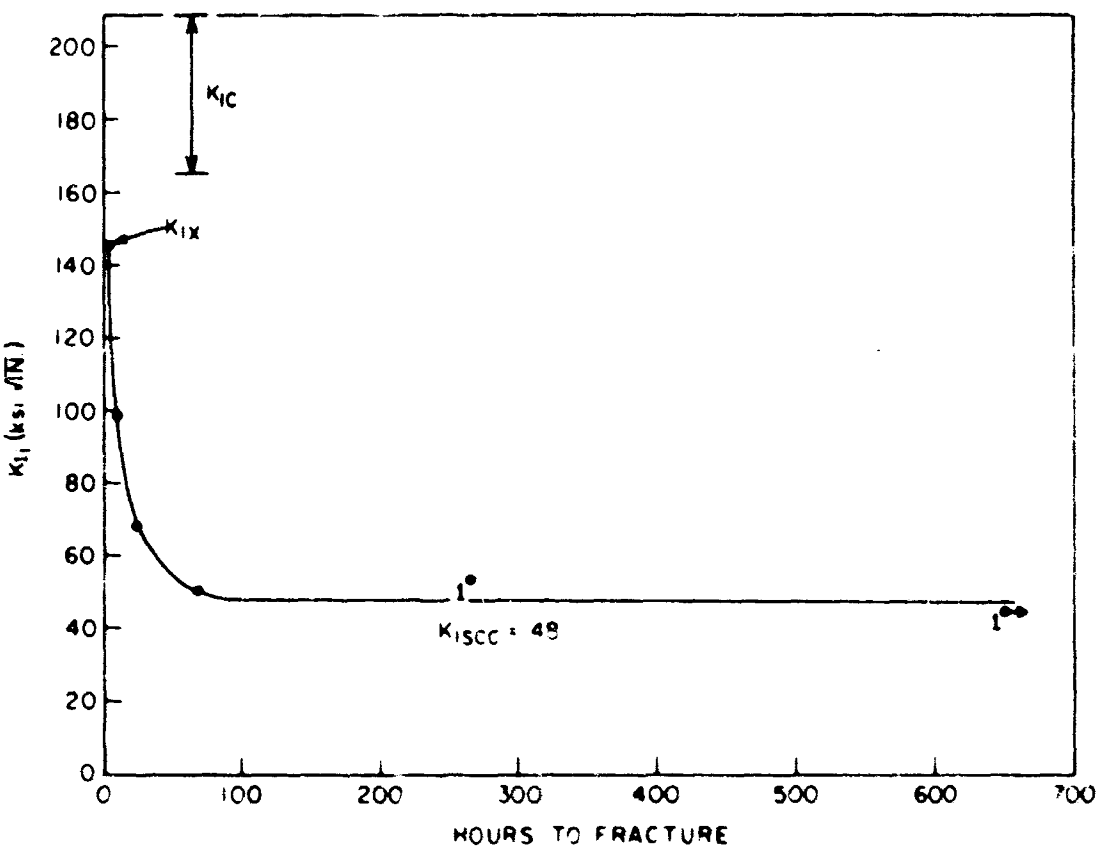

Figure 3 - Stress corrosion of Plate A

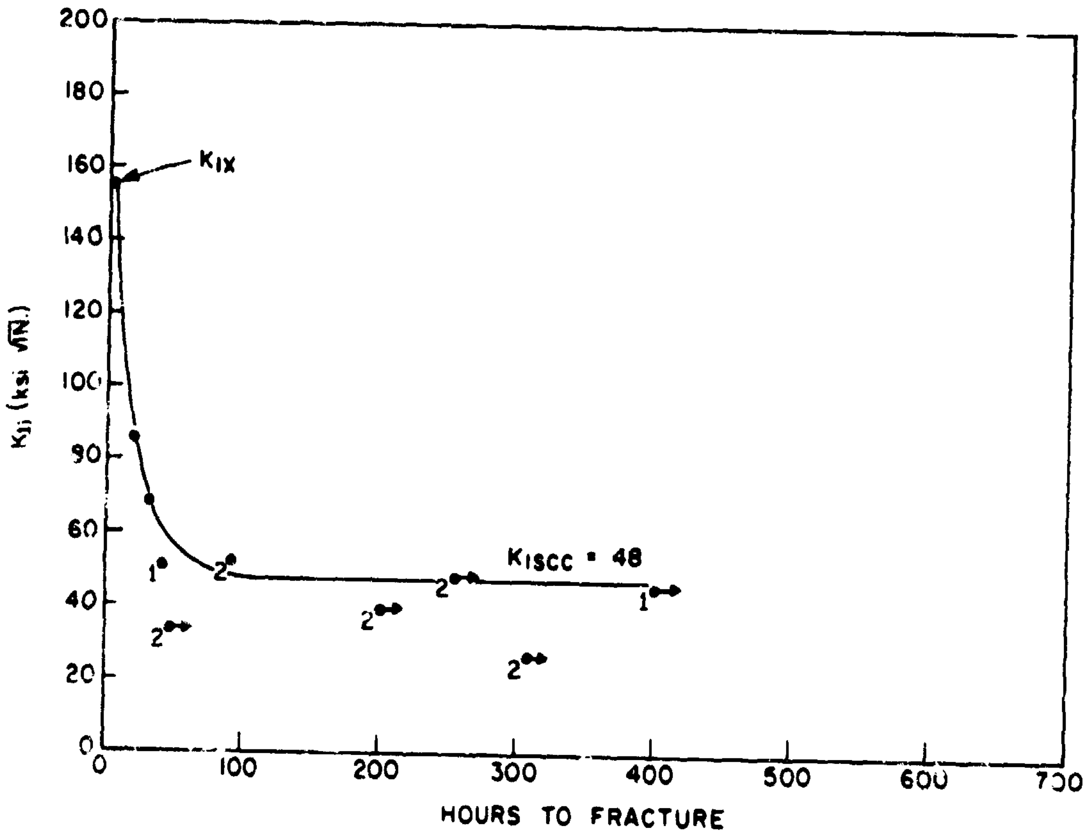

Figure 4 - Stress corrosion of Plate B

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Sandoz, G. and Newbegin, R. L.

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